UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
AIR QUALITY

Uinta Basin Composition Study

Scope of Work

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Project Organization

This composition study has been proposed by the Utah Division of Air Quality (UDAQ) and has been endorsed by Utah State University, and EPA Region 8. Individual members of these agencies and their associated project responsibilities are outlined in Table 1.

Table 1: Project participant responsibilities

Individual(s)	Responsibilities
Lexie Wilson **Environmental Scientist, UDAQ**	• Project management • Data analysis of composition data • Host informational stakeholder meetings
Whitney Oswald **Technical Analysis Section Manager, UDAQ**	• Project oversight • Review final, progress reports

Sheila Vance **Environmental Scientist, UDAQ**	• Stakeholder outreach
Seth Lyman **Director, USU Bingham Entrepreneurship and Energy Research Center**	• Collection of pressurized liquid samples for carbonyls analysis • Flashing of pressurized liquid, carbonyls analysis • Comparison of *U*Lend research results to Composition Study results • Prepare final, progress reports
Trang Tran **Senior Researcher, USU Bingham Entrepreneurship and Energy Research Center**	• Analysis of raw composition data • Generation of speciation profiles • Entry of speciation profiles to SPECIATE database • Use of Speciation Tool on speciation profiles to prepare them for use in SMOKE • Prepare final, progress reports
Michael Pearson **Oil & Gas Lab Manager, Alliance Source Testing (AST)**	• Prepare Quality Assurance Project Plan • Attend information stakeholder meetings (in person or remotely) • Deliver data to Utah State University
AST Laboratory Technicians	• Analyze pressurized liquid and raw gas samples for hydrocarbon composition • Simulate flashing of pressurized liquid sample for hydrocarbon composition • Determine API gravity and Reid Vapor Pressure for all samples
AST Field Technicians	• Collect pressurized liquid and raw gas samples from selected, pre-approved oil or gas wells

Background

The Uinta Basin has had documented exceedances of the National Ambient Air Quality Standard (NAAQS) for ozone during wintertime inversions. The precursor chemicals for ozone formation are nitrogen oxides (NOx) and volatile organic compounds (VOCs). The largest emission source for these ozone precursors in the Uinta Basin is oil and gas production and exploration processes. Research has shown that VOCs are the most effective ozone precursor to control. To further understand the effects of VOC emissions it is necessary to identify the specific species that make up these VOC emissions. Some species are much more reactive than others and have a more profound impact on ozone formation. Speciated data improves the ability to estimate emissions in the Basin both for permitting

and inventory purposes. Additionally, the data can improve the accuracy of the chemistry used in the photochemical model Utah Division of Air Quality (UDAQ) relies on to identify and test control strategies and that support the development of State Implementation Plans (SIP).

A speciation profile represents the average chemical composition of emissions from a grouping of sources. Speciation profiles are generated by collecting several samples from emissions sources, analyzing those samples for a total percentage of each chemical species present, and then averaging those percentages over all samples in the group. The Western Regional Air Partnership (WRAP) developed four oil and gas speciation profiles for the Uinta Basin area of Utah (Figure 1). These profiles were based on source groupings according to well or equipment type: coal-bed methane wells, non-coal-bed methane wells, oil tanks, and condensate tanks. However, the WRAP Phase III profiles used data collected via a voluntary operator survey. In many cases, these profiles were created from relatively small groups of emissions sources; sometimes the speciation profile only represents one emission source. Because the data collected were limited, a large amount of data extrapolation was necessary to fill gaps in the dataset. While limited, these profiles are currently the most representative profiles available for the Uinta Basin. As such, UDAQ currently uses the four WRAP Phase III speciation profiles to inform our atmospheric modeling. However, more robust speciation profiles could result from averaging directly measured chemical species from a larger group of emissions sources.

P_NUMBER	Name	Number of individual profiles
UNT01	Uinta Basin Produced Gas Composition from CBM Wells	3
UNT02	Uinta Basin Produced Gas Composition from Non-CBM Wells	28
UNT03	Uinta Basin Flash Gas Composition from Oil Tanks	1
UNT04	Uinta Basin Flash Gas Composition from Condensate Tanks	5

Figure 1: Speciation profiles from WRAP Phase III

Emissions released from oil and gas products vary depending on the composition of the oil or gas itself (related to the geologic formation from which the oil or gas is sourced), as well as the type of equipment from which the emissions are released. Emissions from upstream and midstream oil and gas sites may come from equipment such as oil or condensate tanks, pneumatic controllers and pumps, separators, truck loading, dehydrators, etc. The composition of emissions generated from these different equipment types can vary. For instance fugitive emissions, of which raw gas sampling is representative, will have a

very different composition than flash gas emissions from an oil tank. Therefore, we propose generating speciation profiles based on both equipment type and geologic formation.

Speciation profiles will be useful in both permitting and emissions inventory undertakings. Permitting engineers are responsible to review composition data that oil and gas industry members submit to UDAQ before beginning operations on a given site. The submitted composition data are provided as a representative sample for the site of interest, but currently, there exists no method to verify the accuracy of operator-submitted data. The speciation profiles produced as a part of this study will provide baseline values for the composition of oil or gas coming from a given geologic formation, thereby introducing verification schema to our permitting process. Additionally, a new collection of formation-specific speciation profiles may allow UDAQ to generate default composition data for operators to use based on their location in the Uinta Basin, potentially saving operators time and money by not requiring industry members to submit their own composition data.

Emissions inventories rely on reported activity data from an oil and gas operations as well as emission factors, which act as multipliers to determine total emissions output from any given source. Here, similar to permitting, new composition data will allow for verification of operator-submitted composition data and emission factors. Additionally, our selection of improved speciation profiles will enable us to improve or even develop default emission factors (for calculating tanks emissions for example) for oil and gas operators to use when submitting to the emissions inventory, allowing them the option to bypass use of the emissions calculation software, like E&P Tanks, entirely while still employing a location-specific data set. This is especially useful for small operators, which make up a large percentage of the operators in the Basin

Finally, an enhanced set of speciation profiles will help improve our atmospheric modeling results. After our speciation profiles are submitted to EPA's SPECIATE database, a speciation tool will map each chemical species to a chemical grouping that can be digested by the emissions processing tool SMOKE, and can then be used with our photochemical model CAMx. Utilizing well-defined speciation profiles in our model will enable us to improve the performance of our model by more accurately modeling the chemistry specific to the Uinta Basin. As ozone levels continue to rise in the Uinta Basin and a SIP becomes imminent, improved atmospheric model output may decrease the likelihood of excessive regulatory action.

Problem Statement

Speciation profiles currently in use by the Utah Division of Air Quality (UDAQ) may not be representative of emissions composition from oil and gas sources in the Uinta Basin, primarily due to small sample sizes from which the profiles were generated and lack of geologic formation resolution. The proposed composition study would provide UDAQ with improved speciation profiles for use in photochemical

modeling and inventory collection. Additionally, having a robust set of composition samples and results can allow UDAQ to establish emission factors that better represent the specific products in the Basin such that sources can provide more reliable emission inventories to the State and EPA.

Project Description

Raw gas and pressurized liquid samples will be collected from 70 wells across state jurisdiction in the Uinta Basin. These 70 wells will be representative of the major geologic formations from which the majority of wells in Uinta and Duchesne counties extract oil and gas products. These wells are operated by a diverse group of companies. Specific operator and location information from all sample and analysis data will be shared with the State. If specifically requested by the cooperating companies, this data will be anonymized by a third party, Utah State University, before being delivered to the state. This data will ultimately be used to create finalized speciation profiles. The proposed composition study will provide UDAQ with improved speciation profiles for use in photochemical modeling, inventory collection, and permit distribution. Specific analyses will include the following:

- Composition of pressurized liquid samples, including C1 to C10 and BTEX
- Simulation of flash gas using VMG software, including composition (C1 to C10 and BTEX) and Gas-Oil Ratio (GOR)
- Reid vapor pressure and API gravity of depressurized liquid sample
- Carbonyl composition of pressurized liquid samples (only for ~ 15% of the total samples collected)

Contracting

UDAQ will contract Alliance Source Testing (AST) to collect samples from upstream oil and gas sources throughout the Uinta Basin, as well as conduct complete laboratory analysis for the composition of those samples. AST worked with Wyoming Department of Environmental Quality during their Oil and Gas Production Site Fugitive Component and Combustor Emission Study. For this study, AST collected and analyzed pressurized gas, oil, water, and tank oil samples from more than 100 upstream oil and gas production sites across Wyoming's Upper Green River Basin using standardized GPA and ASTM methods. All samples were analyzed for hydrocarbons up to C10 and BTEX. AST demonstrated a high level of quality control and assurance throughout sample collection and analysis for Wyoming DEQ. Beyond their documented experience, AST also worked with UDAQ to provide sampling and analysis practices that will be effective on the waxier products of the Uinta Basin (as compared to other oil and gas basins in the intermountain west).

In addition to the required experience to complete the analyses associated with this study, AST has also agreed to meet the following requirements:

- Previous experience collecting raw gas samples from flowing natural gas streams at producing oil or gas well sites
- Previous experience collecting pressurized liquid samples from the separator at producing oil or gas well sites
- Ability to work with a flexible start date (this start date will be in the summer months)
- Ability to travel to remote sites in the Uinta Basin for entirety of sampling period
- Expertise in installation of sampling ports in the instance of oil or gas sites that do not have existing sampling ports installed
- Cooperation and coordination with operators from oil and gas industry stakeholders on site
- Adherence to all site-specific safety protocols
- Experience in gas chromatography and VMG simulation
- Ability to deliver analysis results in a timely manner, including extended composition data, API gravity, RVP, VMG output, and GOR for all samples
- Completion of bubble point quality assurance tests to verify sample and analysis integrity on all samples.
- Quality assurance and quality control measures during data review before final products are delivered to UDAQ
- Continuous communication of sampling and analysis progress to UDAQ
- Ability to provide all raw data to a third party to be anonymized before delivery to UDAQ – **Note:** Only if required by cooperating companies. Otherwise all raw data without anonymization will be delivered directly to UDAQ.
- Delivery of a final report describing collection and sampling methods, raw data (anonymized when necessary by Utah State University), analysis, and uncertainties related to the study.

Outreach Prior to Field Data Collection

To be able to collect samples and analyze data according to project objectives UDAQ requires the cooperation of oil and gas producers in the Uinta Basin. UDAQ has established working relationships with several operators in the Basin through previous scientific studies and rulemaking efforts. Additionally UDAQ has worked through the Western Energy Alliance (WEA) who has many members with operation in the Basin and has been very helpful in facilitating communication and feedback on the previously mentioned studies and rulemaking.

UDAQ will solicit companies to allow a third party contractor to collect samples from their well site and equipment and additionally allow members of Utah State University Bingham Research Center to perform additional analysis and testing on these selected well sites. This will require significant coordination and cooperation among all parties. Regularly scheduled meetings and phone calls with the group will be held to maintain communication on progress of the project and discussion of any issues or concerns.

After contacting individual operators and receiving initial positive interest, a detailed plan of what the project entails, the type of samples, and type of testing to be performed will be provided to those operators. A group meeting will be facilitated to allow discussion and questions to be asked and answered. UDAQ will then assess what operators will be willing to participate in this study and enter into informal agreements for access to their well site. Once it is known which companies are participating in the study, wells owned by these company will be randomly selected based upon the criteria provided in the following section. UDAQ will provide this list of wells to the operators and obtain agreement on these specific wells. Well sites can be negotiated if it can be a "like for like" exchange, if the operator requests.

For the companies that participate, all analytical and testing results will be provided to them.

Site Selection & Field Data Collection

In order to achieve the best possible data set, UDAQ screened all existing oil and gas wells that report to the Division of Oil, Gas, and Mining (DOGM) for certain criteria that should improve the quality of the finalized composition data.

Geologic formations with high concentrations of wells were identified using a collection of all wells that reported to DOGM as of March 2018 (Figure 2).

Wells that qualify as potential candidates for sampling passed the following screens:

1. Well must be currently producing.
2. Well must be either and oil well or a gas well (exclude coal bed methane wells, water injection wells, etc.).
3. Well must be within Uintah, Duchesne, or Carbon counties (general vicinity of the Uinta Basin).
4. Well must pull product (oil or gas) from one of the top 6 major geologic formations (See Figure 2) on which most wells in the Uinta Basin are concentrated.

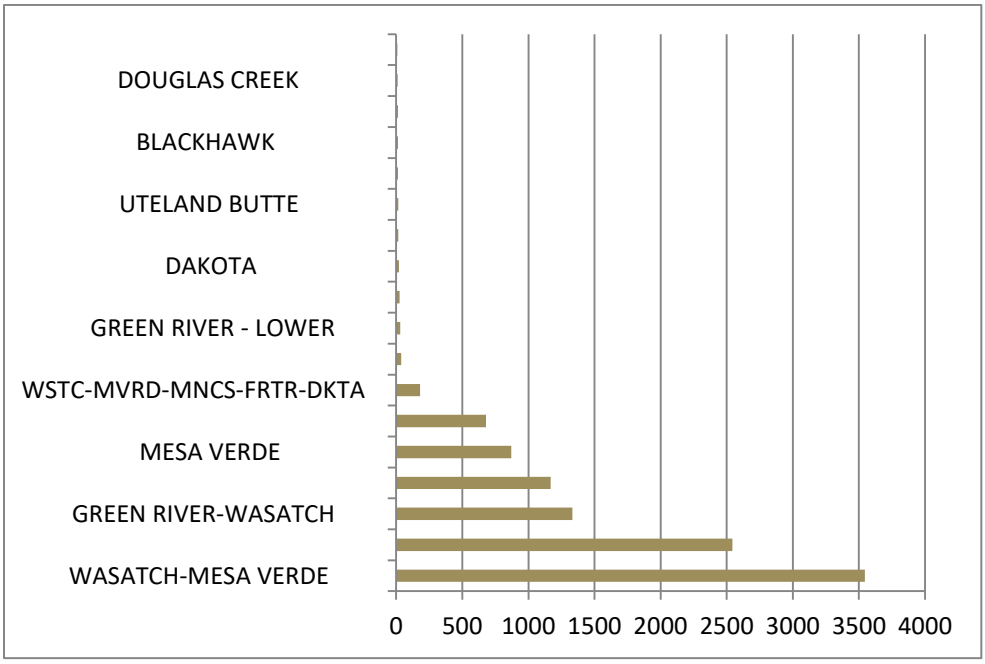

Figure 2: Number of wells extracting product from geologic formations in the Uinta Basin (includes all wells in DOGM database as of March 2018 before screening).

One final screen was applied in which only wells located on State of Utah jurisdiction were selected for sampling. The remaining formations and well counts that draw form these formations are shown in Table 2.

Table 2: Number of oil and gas wells per formation following screening.

Formation	Wells
GREEN RIVER	770
GREEN RIVER-WASATCH	856
MESA VERDE	11
WASATCH	169
WASATCH-MESA VERDE	293
Grand Total	**2099**

Figure 3 shows wells that will be good candidates for sampling as a part of this composition study. While only 70 wells will be finally selected for sampling, all eligible wells are shown here in the case of companies that opt out of participation in the composition study, wells that lack sampling ports, or wells that are otherwise inadequate for high-accuracy sampling. 20 samples will be collected from both the

Green River and Green River-Wasatch formations, while 10 samples will be collected from the Mesa Verde, Wasatch, and Wasatch-Mesa Verde formations. If the outlined number of wells cannot be accessed in a particular chosen formation, sampling will be equally distributed among the other remaining formations such that a 70-sample total is maintained.

Companies that opt out of composition study participation will be removed from site selection prior to the beginning of sampling. Removed wells will be replaced by wells that also passed the various screens and belong to companies who are willing participate in the composition study. This site selection menu will be shared with Utah State University and AST in order to determine the final 70 wells to participate in the composition study. Operators of these wells will also be consulted on site selection to ensure optimized safety and sample integrity at the site.

Field technicians from AST will visit these 70 wells accompanied by company representatives, should those representatives wish to attend sampling events.

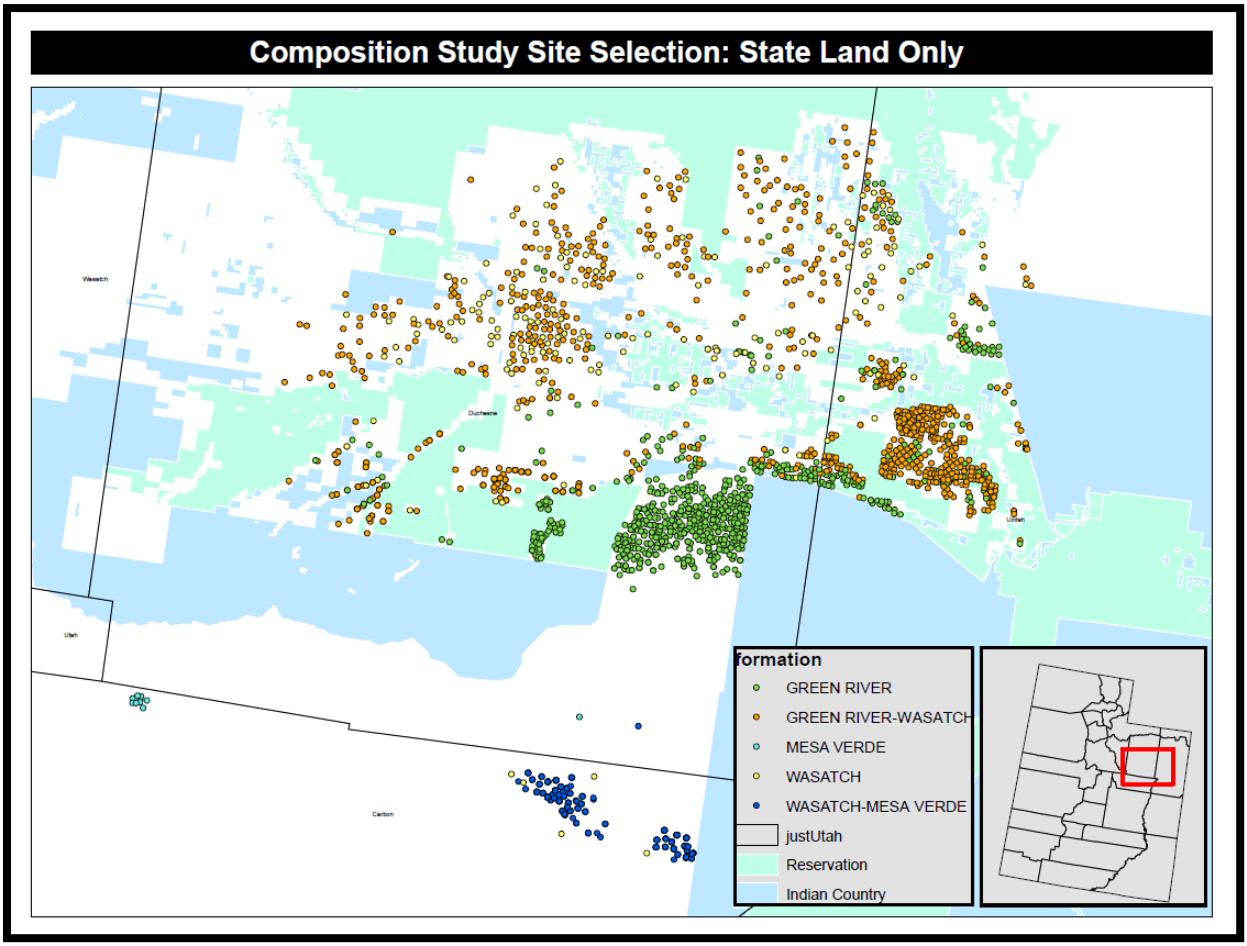

Figure 3: Oil and gas wells in the Uinta Basin that are good candidates for composition sampling as part of this study

Detailed sampling methods are outlined in Sampling Methods on page 13.

Once a schedule is agreed upon by UDAQ and AST, then AST will not go to great lengths and expenses to resample remote wells that were not ready at the agreed upon, scheduled time. Any samples that cannot be collected in accordance with the agreed upon schedule for reasons beyond the control of AST (e.g., sample ports not installed, well not operational, force majeure, etc.) will be removed from target sample collection list unless UDAQ agrees to cover additional mobilization charges.

NOTICE REGARDING SITE SELECTION AND LAND JURISDICTION

At the time this scope of work was drafted, only oil and gas wells on State of Utah lands were selected as candidates for sampling. Should the Ute Tribe or EPA determine that they would like to participate in this composition study *before* the date on which site sampling will begin by AST, a secondary site selection plan will be derived from the wells that passed screening including these additional jurisdictions. In this scenario, 70 samples will still be collected but those samples will have higher spatial, formational, and company variability.

Analysis & Reporting

AST will complete the specific analyses outlined in Analytical Methods on page 15.

Utah State University will complete the following analyses with the composition reports from AST:

- Separate composition data by 1) sample type (pressurized liquid, raw gas, flash gas simulation), 2) geologic formation
- Average chemical species' weight percentages in the same sample type and geologic formation groups (these are *speciation profiles*)
- Enter speciation profiles into the SPECIATE database. Process profiles with the Speciation Tool to prepare the profiles to be incorporated into SMOKE.
    - UDAQ will collaborate with USU on this task
- Compare canister samples/analysis from *U*Lend* high flow experiment to raw gas composition data
- Compare DNPH samples/analysis from *U*Lend* experiment to (flashed) pressurized liquid carbonyls analysis
    - Incorporate carbonyl data into profiles where possible

*Utah State University is also being contracted by UDAQ to complete what is referred to as the *U*Lend experiment, in which USU will visit the same oil and gas well pads visited in this Composition Study to conduct emissions measurements with a high flow device, alongside canister and DNPH samples of emissions.

UDAQ will complete the following analyses with the composition reports from AST and analysis results (speciation profiles) from USU:

- Compare directly sampled/analyzed composition data associated with this study to composition data received via…
    - Request to companies to provide composition data
    - Pulling existing composition data from permits and oil/gas emissions inventory submissions
- Generate default values for composition in the oil and gas inventory workbook based on the geologic formation from which a production facility pulls its product (see Wyoming oil and gas inventory workbook for reference)
- Generate new emission factors from the composition data where possible, i.e. tanks

Distribution of Data & Analysis Results

AST will distribute all analysis results, final reports, and quality assurance reports to UDAQ. In the case of a formal company request to keep analysis data anonymous, AST will deliver the results pertaining to that company to Utah State University. USU will anonymize the data and then deliver to UDAQ.

Sampling Methods

Lab technicians from AST will be responsible to adhere to the following sampling practices at each well site:

Standardized Methods:

- Use of GPA 2166: Obtaining Natural Gas Samples for Analysis by Gas Chromatography
- Use of GPA 2174: Obtaining Liquid Hydrocarbons Samples for Analysis by Gas Chromatography
    - Collect the sample from a location (e.g., sample probe, sight glass fitting) with routine oil circulation (e.g., avoid collecting stagnant HC liquids from the bottom of the separator HC liquids layer).
    - Use a sample collection rate of 60 ml/min or less (start sample collection at a slow rate and then increase to target sampling rate); record the sample collection pressure and temperature at the start, middle, and conclusion of sample collection; and be aware of potential biases for samples collected in CV [constant volume] cylinders.
    - When collecting the sample, ensure complete purging of the sample collection equipment.

Best Practices:

- Record the sample collection pressure and temperature at the start, middle, and

conclusion of sample collection, and monitor these parameters throughout the sample collection. Note any anomalous changes in these measurements. A separator HC liquids temperature measurement during sample collection, in the vicinity of the sample collection location if possible, is recommended for bubble point pressure (P_{BP}) and sample cylinder pressure (P_{SC}) calculations.

- Use calibrated and highly accurate pressure gauges and temperature sensors during all sample collection and laboratory procedures.
- Separator temperature should be collected from liquid in the separator, not gas.
- The implication for sample collection is to attempt to maintain a steady separator temperature and pressure for one or more well cycles prior to sample collection and collect samples within 30 minutes of the well cycle end.
- Maintain sample cylinder temperatures following sample collection to avoid paraffin formation in the sample, particularly as this study deals with waxy crudes from the Uinta Basin.

Additionally, lab technicians will collect the following observational parameters:

- Well site facility name, operator name, latitude/longitude coordinates, API well IDs
- Time of well cycle completion
- Time of sample collection (*collect samples within 30 minutes of well cycle end*)
- Sample pressure and temperature (using calibrated and highly accurate sensors) at the beginning, middle, and conclusion of sample collection
- Start time and end time of sample collection
- Separator hydrocarbon liquids temperature measurement during sample collection near the sample port (again using highly calibrated sensors)
- Ambient air temperature
- Sample collection rate, indicate less than or greater than 60 ml/min
- Separator type (vertical/horizontal)
- Sample port type
- Sample port location on separator, sample port location relative to water/hydrocarbon liquids boundary (*e.g. avoid collecting stagnant HC liquids from the bottom of the separator hydrocarbon liquids layer*)
- Number of tanks on site
- Description of tanks (tank type, downcomer or side fill, etc.)
- Internal tank temperature, either via temperature gauge or intrinsically safe IR thermometer measurement through the thief hatch
- Type of well (oil or gas well)

If possible, the following parameters should also be collected (either in the field or via phone interview with operators)

- Approximate age of well
- Approximate duration of well operation/production prior to sample collection
- Gas, oil/condensate, and water production volumes

Analytical Methods

AST will perform the following analyses following sampling collection:

- Raw gas composition according to GPA 2286: Method for the Extended Analysis of Natural Gas and Similar Gaseous Mixtures by Temperature Programmed Gas Chromatography
    - Required analysis of C1 to C10 and BTEX (extended hydrocarbon analysis)
- Pressurized liquids composition according to a GPA 2103M: Tentative Method for the Analysis of Natural Gas Condensate Mixtures Containing Nitrogen and Carbon Dioxide by Gas Chromatography
    - Required analysis of C1 to C10 and BTEX (extended hydrocarbon analysis)
    - AST modifications to GPA 2103 will include a simulated distillation analysis to extend the report to C36+ and a detailed hydrocarbon analysis run on the FID for improved speciation. The TCD analysis will be C1-C6+, Air, and CO2. The Air/N2 will be removed from the analyses if determined to be a sample collection artifact. Well site operators, or other company personnel, should document if N2 is native to the formation. The molecular weight and densities of the C10+ fraction will be calculated from the GC analysis
- Flash gas composition and gas-oil ratio (GOR) via VMG simulation with input from pressurized liquids composition analysis and operating parameters taken at the oil or gas site. AST can use the specific field temperature and pressure for the FGOR calculations or a single temperature and pressure specified by UDAQ.
    - Determination of API gravity of depressurized liquid (oil or condensate) and Reid vapor pressure (RVP) of depressurized liquid (oil or condensate) based on the VMG estimate of the post-flash oil composition
    - Ensure that PMS/EOS FGOR and P_{BP} calculations be conducted using HC liquids composition with the nitrogen mathematically removed

Finally AST will include the following values in their reporting for both physical and simulated analyses:

- Temperature of sample at which analysis was conducted
- Pressure of sample at which analysis was conducted
- Total molecular weight
- Weight percentages

- Analysis date & time
- Analysis type

Quality Assurance and Control Measures

AST will follow quality assurance and control measures as appropriate in association with the collected samples and analyses requested above.

- Measure sample pressure and temperature during sample collection and during lab analysis with highly accurate, calibrated instruments.
- Determine an PSM/EOS calculated PBP/PSC to identify potential anomalies with the sample, and flag anomalous results for further scrutiny.
- As appropriate, adjust N_2 levels in HC liquids compositions prior to PSM/EOS calculations (e.g., if sample N_2 is determined to be sample collection artifact air, set N_2 level to zero).
- Reproducibility and repeatability limits based on the representative methods will be checked using certified liquid and gas calibration standards. These limits will be reported and serve as the concentration (mole %) uncertainty estimates for the pressurized gas and liquid C1-C6+ sample concentrations. Manufacturer's uncertainly will be reported for measurement gauges used in the study.
- Sum of chemical species' weight percentages must equal 100%.
- When possible, compare analysis results to similar historical samples.

AST will also provide UDAQ with a Quality Assurance Project Plan (QAPP) that further outlines the quality assurance and control measures that will be taken throughout sampling and analysis.

Use of Existing Data

Composition data are routinely collected by UDAQ as part of the permitting process. In applying to receive a permit (referred to as an Approval Order, or AO), an oil and gas company must provide composition data from the well that is being permitted. Often, companies will provide UDAQ "representative" composition data, or data that has been previously sourced from another well but is assumed to produce a similar product to the well being permitted.

All previously submitted composition data were collected from UDAQ permitting records before the onset of this composition study. These composition data were sorted through a rigorous screening process to eliminate data prone to errors and mistakes.

Screening Process

Tier 1

Composition data were only considered for physical pressurized liquid, raw gas, and flash gas composition from upstream oil or gas wells. Midstream facility data from compressor stations, gas plants, etc. were not considered. Water injection and water disposal facilities were also not considered.

Temperatures and pressures under which the oil, condensate, and gas samples were analyzed were also scrutinized. Black wax oil products common to the Uinta Basin have a pour point of about 130° F, so any analysis of pressurized hydrocarbon liquids that reported temperatures below this cutoff was screened. Pour points vary for other products such as yellow wax and condensate, but no screens were applied for those products. Any analysis conducted below a pressure of about 30 psi was also screened; this pressure cutoff was determined by an experienced engineer who has reviewed a multitude of oil and gas permits.

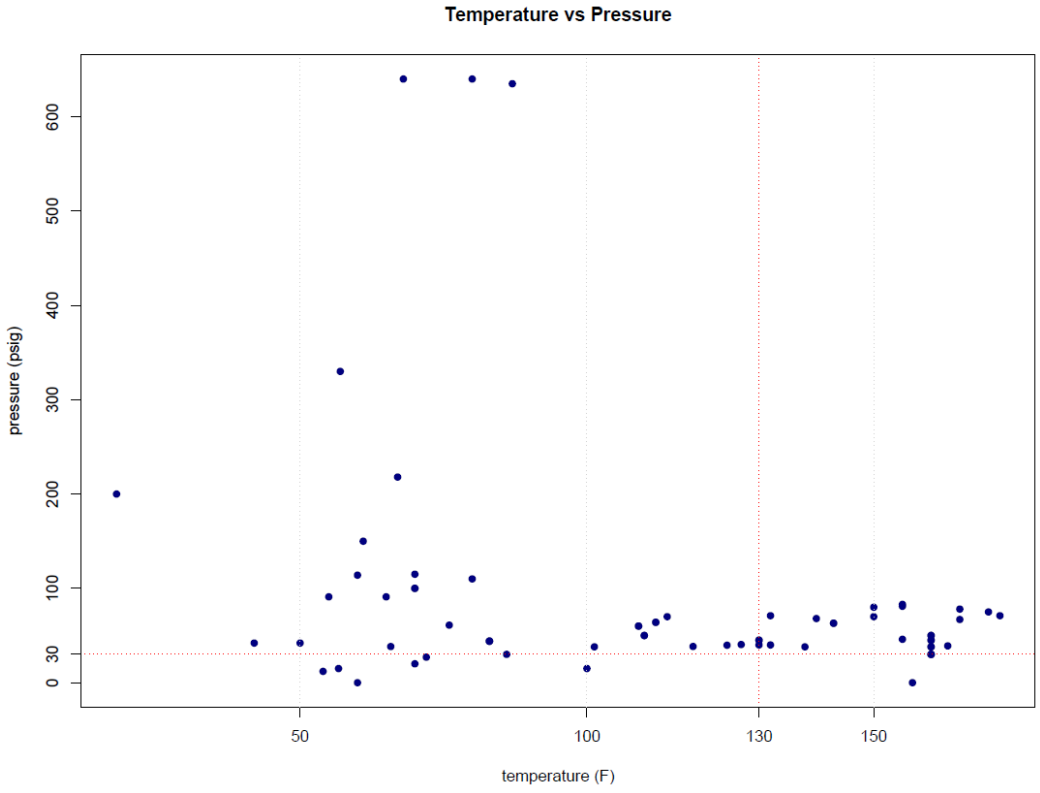

Figure 4: Temperature versus pressure of available composition data analysis sets. Viable datasets have temperatures and pressures in the upper left quadrant of this figure.

Composition datasets that did not include sufficient information for screening, such as lack of analysis type, were removed.

Finally, any composition datasets that grouped heavier hydrocarbons into one category were eliminated. These were listed as “Hexanes +” or “octanes +.” The screening process required a minimum of 10 unique hydrocarbon categories (however, “decanes +” was deemed acceptable).

Tier 2

Total molecular weight percentages were calculated for each chemical species category by the laboratory. These percentages were verified by UDAQ by simply summing over all individual species percentages and compared to the laboratory-reported total molecular weight percentage (presumably 100%). In some cases, these two totals did not agree, and those data sets were screened.

UDAQ sums were calculated by placing chemical species into the categories listed in Table 3, regardless of how the laboratory grouped the chemical species.

Table 3: Hydrocarbon grouping categories for chemical species identified in existing composition data.

Hydrocarbon Grouping	Chemical Specie
C1	• Methane
C2	• Ethane
C3	• Propane
C4	• n-butane • isobutane
C5	• n-pentane • dimethylpropane / neopentane • isopentane • cyclopentane
C6	• dimethylbutane 2,2 • dimethylbutane 2,3 • methylpentane 2 • methylpentance 3 • n-hexane • methylcyclopentane • cyclohexane
C7	• n-heptane • methylhexane 2 • methylhexane 3 • methylcyclohexane
C8	• n-octane • trimethylpentane 2,2 4
C9	• n-nonane • trimethylbenzene 1,2 4
C10	• Decanes (+)

B	• beneze
T	• toulene
E	• ethylbenzene
X	• M xylene • P xylene • O xylene

Gas-Oil Ratio (GOR) was calculated for datasets in which the necessary inputs were made available. These calculations were completed according to the Vasquez-Beggs equation. These GORs were then compared to typical GOR ranges outlined in from EPA's "Information Collection Request Supporting Statement: Information Collection Report for Oil and Gas Facilities." (Table 4)

Table 4: GOR ranges by well type

Well Type	GOR range
Heavy oil well	<= 300
Light oil well	300 < GOR <= 100,000
Wet gas well	100,000 < GOR <= 1,000,000
Dry gas well	GOR > 1,000,000
Coal bed methane well	-

Any GOR outside these EPA ranges were screened. Additionally, GORs were subject to a box and whisker plot analysis to remove outliers.

After screening, 19 composition datasets remain. These will serve as our historical dataset, and they will be used to compare results from directly measured and analyzed composition data.

Additional Incoming Data

Existing composition data may continue to arrive at UDAQ from oil and gas emissions inventory supporting documentation, newly issued permits, and source registration site-specific samples. These incoming data will be subject to the same screening process outlined above.

Finally, USU will request any additional site-specific samples and composition data from operators in the Uinta Basin. At the operator's discretion, any data delivered to UDAQ via this pathway will also be screened by the method outlined above.

Data Management

Following analysis, AST will forward all data to USU and UDAQ. USU will perform additional analysis and upload all data to a password-protected online storage unit (Box) to be shared with UDAQ. After the final report is released and the project is completed, all data will be uploaded to USU's Digital Commons, where they can be accessed by the public.

Data Review, Verification, and Validation

USU will review all data from AST to verify that total molecular weight percentages equal 100% and that all requested analysis results are present. UDAQ will put all physically collected sample analyses through the same screening process outlined in Use of Existing Data on page 16.

All products from this study, particularly the speciation profiles generated from composition data, will be subject to peer review by members of the oil and gas academic and government community.

Reporting

USU will deliver a final report outlining their methods, analysis, results, and conclusions to UDAQ.

UDAQ will produce a final report detailing the results of our analysis, results, and framework for future work involving the products of this study.

These reports will be delivered to all cooperating agencies that are participating in this study, as well as all oil and gas companies that allowed sampling to occur on their well pads. These reports will also be posted on UDAQ's research webpage for public consumption.